OBSERVATIONS OF NIGHTLY FLIGHT PATTERNS IN SOME COMMON SPECIES OF MOTHS (LEPIDOPTERA)

G. CARRICK

Holt Hall Residential and Field Study Centre, Kelling Road, Holt, Norfolk NR25 7DU.

Introduction

DURING THE EARLY years of this century studies of nightly flight patterns in insects were concerned with pest species and their control. Techniques involved complicated equipment or staying up throughout the night to observe the target species. Williams (1939) did the first detailed work in looking at the nightly flight patterns of insects with his trap at Rothamsted. This allowed a variety of insects from different orders to be studied at the same time. The recent development of a relatively small and portable moth light-trap that allows the night to be divided up into six periods, and its higher catch compared to a standard Robinson moth trap (Carrick & Overall 1997), has permitted studies on the segregation of species according to preferred flight times. This paper outlines a season's results from this trap, which show the main flight strategies adopted by different moth species.

Methods

The Carrick-Overall trap was set regularly between June and September 1994 at Holt Hall Residential and Field Study Centre, near Holt in north Norfolk. The trap was programmed to start at sunset and to sample the night in six equal periods until sunrise. This means that period length varied between 65 and 115 minutes, depending on the length of the night. The trap was emptied daily and the species and number of individuals of each species recorded in each section of the trap. The numbers for each species were totalled for each period of the night throughout their flight seasons. Species with overall totals of <30 were not considered unless they exhibited a very distinct pattern of flight throughout the night. Where numbers permitted, a goodness of fit chi-square test was applied to determine whether there was a significant preference for flight in a particular time period. The scientific names and classification used follow Bradley (1998). All times are given in British Summer Time (BST), which is Greenwich Mean Time (GMT), plus one hour.

Results

The data for all the species with sufficient data for analysis are given in Table 1.

For a number of species there was a preference for flight in one or two time periods (Table 1). For some species there was insufficient data for chi-square analysis. However, these species have been included because they show trends that conform with others that do show significance. It is possible to identify four flight strategies; moths showing a preference for period 4 (ie between approximately 1.00 am and 2.00 am BST), early fliers peaking in numbers in periods 1, 2 or 3, late fliers being moths that do not fly in the early part of the night or peak in periods 5 or 6 and moths showing an even distribution throughout the night. This latter group is categorised on the basis that the moth species do not show statistical significance in their distribution throughout the night.

The similarities of the flight patterns within these categories are best seen graphically. The first four species are plotted from each flight strategy given in Table 1 as representative of each of the flight strategies (figures 1 - 4). Numbers of moths m

	Time Period							
Species	1	2	3	4	5	6	Significance	F Strategy
Idaea aversata	1	6	5	14	5	4	p<0.001	Period 4
Biston betularia	1	4	25	33	7	7	p<0.001	Period 4
Alcis repandata	2	9	24	31	9	4	p<0.001	Period 4
Pheosia tremula	1	3	6	15	6	3	p<0.001	Period 4
Agrotis segetum	3	3	7	15	7	2	p<0.01	Period 4
Agrotis exclamationis	38	43	96	183	105	63	p<0.001	Period 4
Noctua pronuba	199	227	216	278	184	106	p<0.001	Period 4
Noctua janthe	18	17	43	77	52	45	p<0.001	Period 4
Discestra trifolii	8	5	9	19	18	5	p<0.01	Period 4
Laconbia oleracea	11	9	24	34	11	2	p<0.001	Period 4
Melanchra persicariae	2	4	1	18	3	4	p<0.001	Period 4
Mythimna comma	2	4	3	10	6	1	N E D	Period 4
Charanyca trigrammica	4	5	11	34	14	11	p<0.001	Period 4
Pseudoips prasinana britannica	0	3	1	10	3	2	N E D	Period 4
Calliteara pudibunda	3	15	3	6	1	0	N E D	Early
Cerapteryx graminis	60	55	33	34	28	14	p<0.001	Early
Mythimna ferrago	1	0	11	3	2	0	N E D	Early
Mythimna impura	4	1	6	3	1	1	N E D	Early
Cosmia trapezina	4	8	16	8	9	6	N S	Early
Autographa jota	2	17	9	8	4	0	p<0.001	Early
Autographa gamma	81	102	59	50	29	20	p<0.001	Early
Laothoe populi	0	0	5	11	4	3	N E D	Late
Phalera bucephala	0	0	5	23	23	2	p<0.001	Late
Eilema lurideola	14	10	13	21	35	37	p<0.001	Late
Spilosoma luteum	2	7	4	13	10	14	p<0.05	Late
Ochropleura plecta	5	5	7	3	13	12	p<0.05	Late
Agrotis puta puta	5	1	4	8	9	5	N S	Even
Noctua comes	10	6	11	16	7	8	N S	Even
Xestia c-nigrum	47	28	44	43	47	36	N S	Even
Mamestra brassicae	10	8	15	19	19	16	N.S	Even
Mythimna pallens	14	19	23	34	20	23	N S	Even
Cosmia trapezina	4	8	16	8	9	6	N S	Even
Mesapamea secalis	18	32	27	40	38	36	N S	Even

Table 1. Flight periodicity in selected species arranged according to flight strategy. (Total No. of moths caught per time period).

are converted to percentages for each of the figures so that species can be compared on the same scale. The species are listed in the table taxonomically according to Skinner (1984).

Some closely related species show remarkable similar flight patterns eg. *Mythimna ferrago, M. impura*, *Autographa jota* and *A. gamma*. These are shown in Figs. 5 and 6 respectively.

Discussion

Of the four flight strategies identified, that showing a peak in period 4 was the most common. The flight patterns are very similar for species in this category. These species were at a very low frequency at the beginning and end of the night. Species that fly early in the night peaked in Period 2 or 3, eg. *Calliteara pudibunda*, *Mythimna ferrago* and *M. impura* (Table 1). By contrast *Cerapteryx graminis* was most frequent in Period 1 and then gradually decreased in frequency as the night progressed.

Species that fly late in the night may be absent in the first two periods, appearing after midnight in Period 3. This was the case for *Laothoe populi* and *Phalera bucephala*, neither of which was seen before midnight (Table 1). There are species that fly at low frequencies early in the night and increase in numbers with time, showing a gradual increase to peak in Period 6 e.g. *Eilema lurideola* and *Spilosoma lutea*.

Graphs are very similar for species that are evenly distributed through the night with most species showing a dip during period 2 and a maximum in either period 4 or 5. Despite the lack of significance when tested against a null hypothesis of no difference between periods there is a definite trend and most could be described as period 4 or late night flyers. It is possible that the frequencies seen in Period 1 represent moths in the immediate locality of the trap when the lamp is illuminated and that they are caught quite quickly, and that it then takes some time for them to undertake dispersal flight and thus encounter the trap.

Some species show two peaks of activity eg. *C. pudibunda*, *Idaea aversata* and *M. comma* (Table 1). Persson (1971) found that females of Noctuid species were active before midnight with a weaker peak later in the night and Ames & Cooter (1991) found that in *Helicoverpa amigera* young unmated females flew further and for longer than mated older females. Sappington & Showers (1992) supported such patterns with *Agrotis ipsilon* where mated females flew about three hours later than unmated ones and for approximately two hours less flying time. Therefore, it would seem that in some species there are individuals, particularly females, entering and leaving the flying population at different times of the night. In species with unmated females flying early and mated females flying later it is possible that this would give two peaks of flight activity if the unmated females settled. Similarly in species where individuals join the flying population as the night progresses, it is easy to see how peak flight activity can occur in period 4.

Few studies of this nature have been carried out for comparison. Williams (1939) conducted his classic study at Rothamsted using a timed trap which divided the night

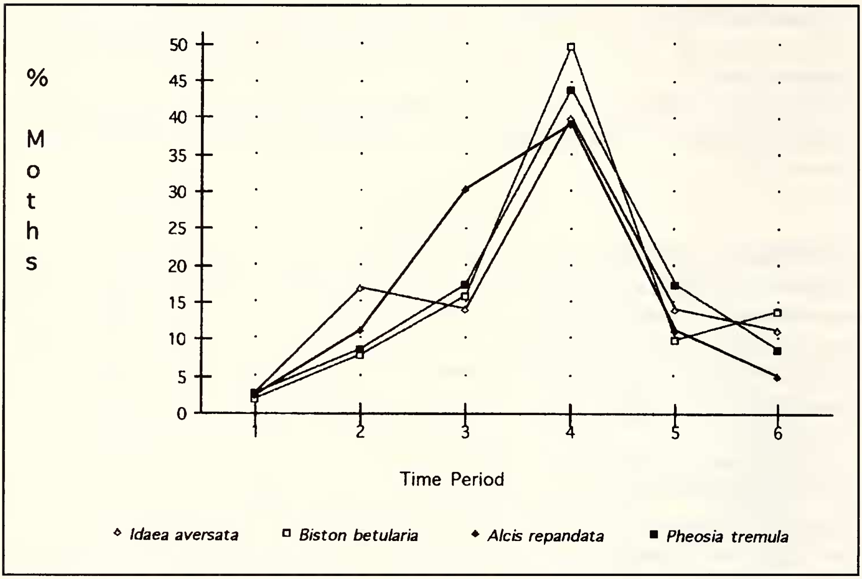

Fig. 1. Species with a preference for Flight in Period 4

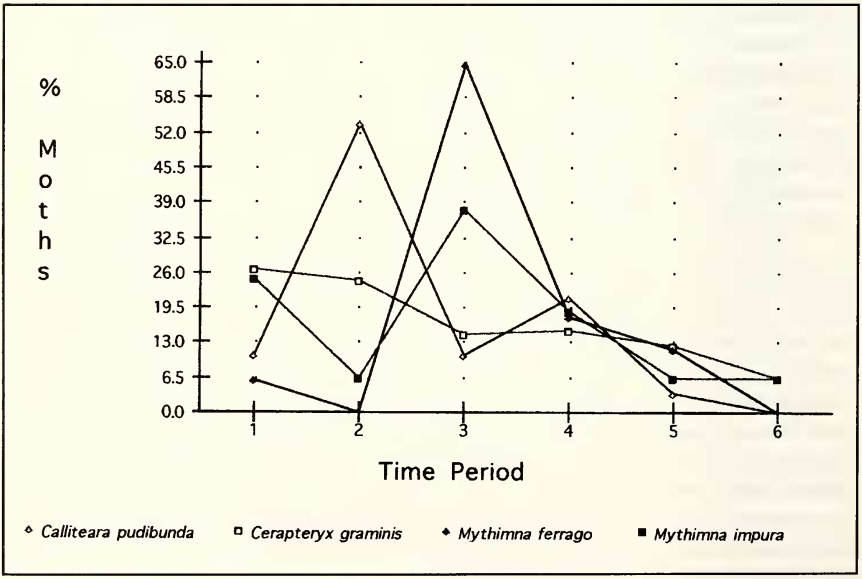

Fig. 2. Species flying early in the night

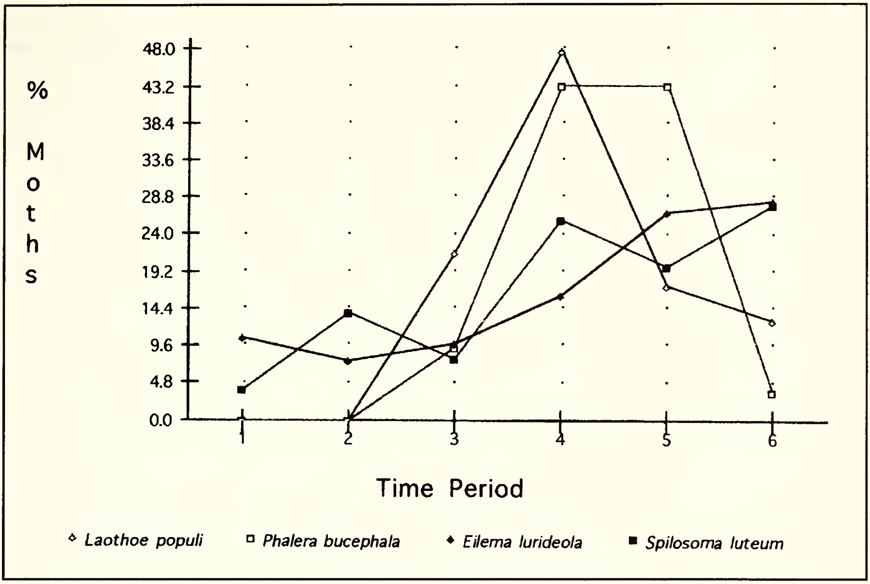

Fig. 3. Species flying late in the night

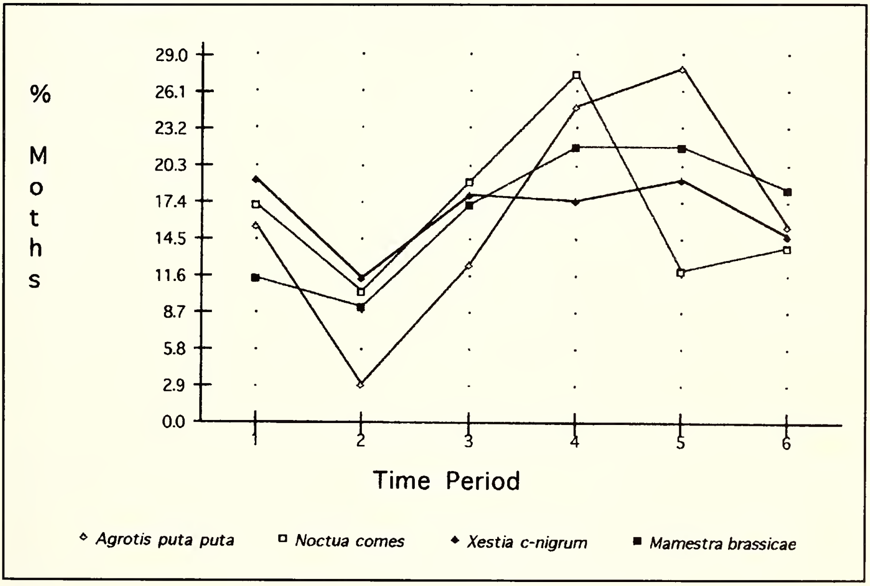

Fig. 4. Species evenly distributed throughout the night

into eight periods. He considered his results mainly in families and few of the species he highlighted have sufficient data for analysis here. However the results for *Eilema lurideola*, *Agrotis exclamationis* and *Mythimna pallens* are in agreement with

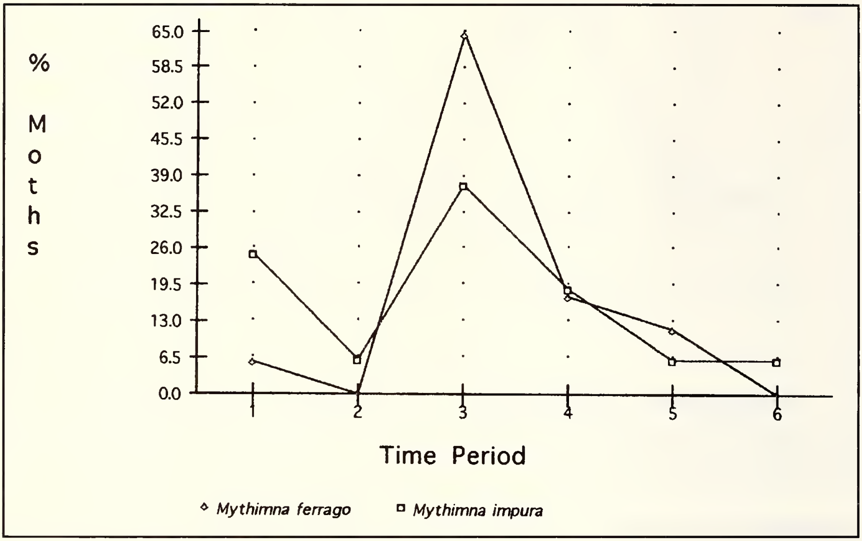

Fig. 5. Flight patterns of *Mythimna ferrago* and *M. impura*

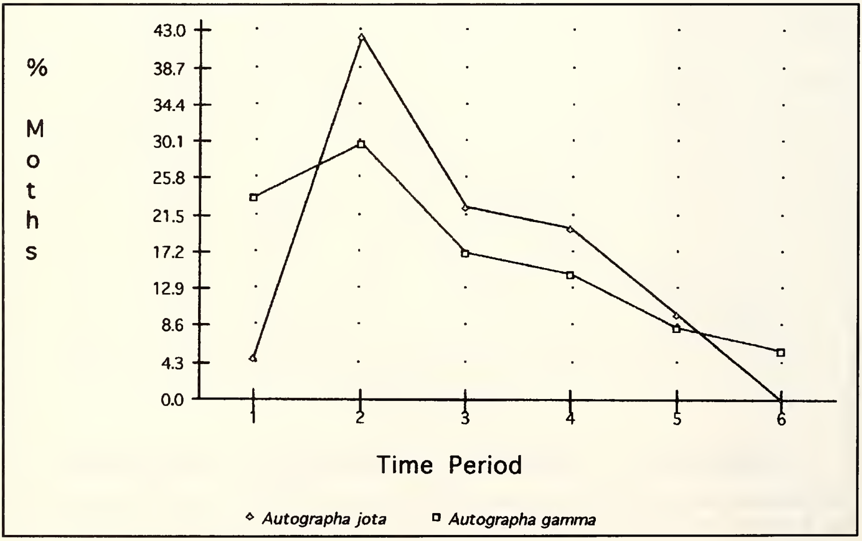

Fig. 6. Flight patterns of *Autographa jota* and *A. gamma*

his study. By contrast he found that *Xestia c-nigrum* peaked in the first half of the night, whereas in this study it was found to be relatively evenly distributed throughout the night.

The two *Spilosoma* species show patterns which confirm Williams (1939) with *S. lubricipeda* peaking earlier in the night than *S. luteum*.

It may be concluded that there is a general pattern of flight activity, with many species showing the greatest activity between 01.00hrs. and 02.00hrs. It was observed that as they came into their flight season, the early specimens of many species were caught in period 4 and it was only after numbers built up in the population that they appeared in other time periods.

Other flight strategies exist with species flying earlier or later in the night. Some of these species are quite conspicuous (eg. *Euproctis similis*) and it may be to their advantage to be most active outside the period of greatest activity as this may also be the time of greatest predator activity eg. bats. For other closely related species the pattern of flight activity may be determined by inheritance eg. *Autographa jota* and *A. gamma* (Fig. 6). The two species of *Mythimna* also show similar flight patterns (Fig. 5). It may be concluded that differences in flight patterns played no part in the divergence of these species.

The results from the timed trap only show flight activity in moths at times when they are phototropic. It is possible that moths may fly at other times when they do not respond to light; such activity cannot be sampled using a light-trap. This limitation of light-trapping was outlined by Williams (1939).

It is possible that some of the catches made in the early time periods for moths that peak in flight activity later in the night, may be due to moths that had gone to cover close to the trap on the previous night, having been attracted to the trap late in the night and then had flight suppressed by the onset of dawn before being caught. This could give the impression of an artificially long nightly flight period for some species.

It is well known that weather conditions can have a considerable influence on moth activity (Williams 1940) as can phases of the moon (Nawinsky & Ekk 1988, McGeachie 1989). No allowance has been made for meteorological conditions or phases of the moon over the time in which trapping occurred. This may account for the spread of some species through the night, with different conditions leading to different nightly flight patterns on a night to night basis. However the concern here is with the general nightly flight patterns of species over a flying season. It is accepted that this may vary from season to season (Williams 1939).

Acknowledgements

Thanks are due to Terry Overall and the Technical Support Team, Applied Sciences at Anglia Polytechnic University, Cambridge Campus for their work in developing the Carrick-Overall trap and in ironing out the initial teething problems. Thanks also to Dr June New of A.P.U. and Dr Brian Davis for their help, support and advice in carrying out this work and for commenting on the text of this paper. The development of the Carrick-Overall trap was made possible through a research bursary from B.E.S.T. Faculty, A.P.U.

References

Ames, N.J. & Cooter, R.J., 1991. Effects of change and mated status on flight potential of *Helicoverpa amigera* (Lepidoptera: Noctuidae). *Physiological Entomology* **16**: 131-144.

Bradley, J.D., 1998. *A Checklist of Lepidoptera recorded from the British Isles*. Bradley & Bradley.

Carrick, G. & Overall, T., 1997. A Light Trap to sample Lepidoptera during different time periods throughout the night. *Entomologist* **116**: 1-10.

McGeachie, W.J., 1989. The effects of moonlight illuminance, temperature and windspeed on light trap catches of moths. *Bulletin of Entomological Research* **79**: 185192.

Nawinsky, L. & Ekk, I., 1988. The swarming outset of Macrolepidoptera observed by light trap as correlated with the moon phases. *Acta Phytopathol. Entomol. Hungarica* **23**: 157-166.

Persson, B., 1971. Influence of light on flight activity of noctuids (Lep.) in South Sweden. *Entomologia Scandinavia* **2**: 215-232.

Sappington, T.W. & Showers, W.B., 1992. Reproductive maturity, mating status and long duration flight behaviour of *Agrotis ipsilon* (Lepidoptera: Noctuidae) and the conceptual misuse of the oogenesis flight syndrome by entomologists. *Environmental Entomology* **21**: 677-688.

Williams, C.B., 1939. The Times of Activity of Certain Nocturnal Insects, Chiefly Lepidoptera, as Indicated by a Light-trap. *Trans. Royal Entomological Soc., London* **83**: 523-555.

– , 1940. An analysis of four years captures of insects in a light trap. Part II. *Trans. Royal Entomological Soc., London* **90**: 227-306.

Corticeus unicolor Pill. & Mitt. (Col.: Tenebrionidae) new to Warwickshire

I was interested to read A.A. Allen's comment on the relative status of *Corticeus fraxini* (Kug.) and *C. unicolor* in the recent *Ent. Rec.* **110**: 168 just a few months after I had taken a specimen of this RDB 3 species in a private woodland in Warwickshire to which I have had access from the owners for nearly ten years. It was one of three found on 9.v.1998 on sap beneath the bark of an oak *Quercus* branch which had been left lying on the ground amongst a pile of other branches during winter felling operations in the wood within the previous two to three years. As the wood contains a sizeable area which is notified as a Site of Special Scientific Interest (SSSI), it is the policy to leave some recently cut and also decaying wood on the ground. The discovery of this species new to the county was just in time to be included in *A Provisional Atlas of the Cleroidea & Heteromera Beetles of Warwickshire* by Steve Lane, Keeper of Natural History at the Herbert Art Gallery and Museum, Coventry where the specimen, determined by Steve Lane, has been retained in the entomology collections. In Hyman & Parsons (1992, *A review of the status of the scarce and threatened Coleoptera of Great Britain,* **1**: 413), as Allen quotes, it is accorded "rare" status "with only four county-divisions for the post-1970 period." It would be interesting to hear whether the species has been found elsewhere since Hyman & Parsons was published. I would like to thank Steve Lane for his unfailing support with identifications and both he and A.A. Allen for encouraging me to publish this note.– B.R. Mitchell, 127 Watling Street, Grendon, Near Atherstone, Warwickshire CV9 2PH.